ARCO Alaska, Inc.
Anchorage Alaska and Plano, Texas

ALPINE

Colville River Crossing

- *Presented to:*
  Alaskan Arctic Pipelines Workshop,
  Nov.8-9, 1999 Anchorage, AK

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Anchorage, Alaska

HDI
Horizontal Drilling International,
Houston, Texas

Baker
Michael Baker Jr., Inc.
Anchorage and Fairbanks, Alaska

HOUSTON CONTRACTING COMPANY ALASKA
Houston Contracting Company,
Offices in Alaska and Houston, Texas

Project Overview

Team Members

ALPINE PROJECT
(ARCO Alaska, Anadarko, Union Texas Petroleum)

Michael Baker Jr., Inc.

- Crossing Engineer
- Program Manager

Houston Contracting Company

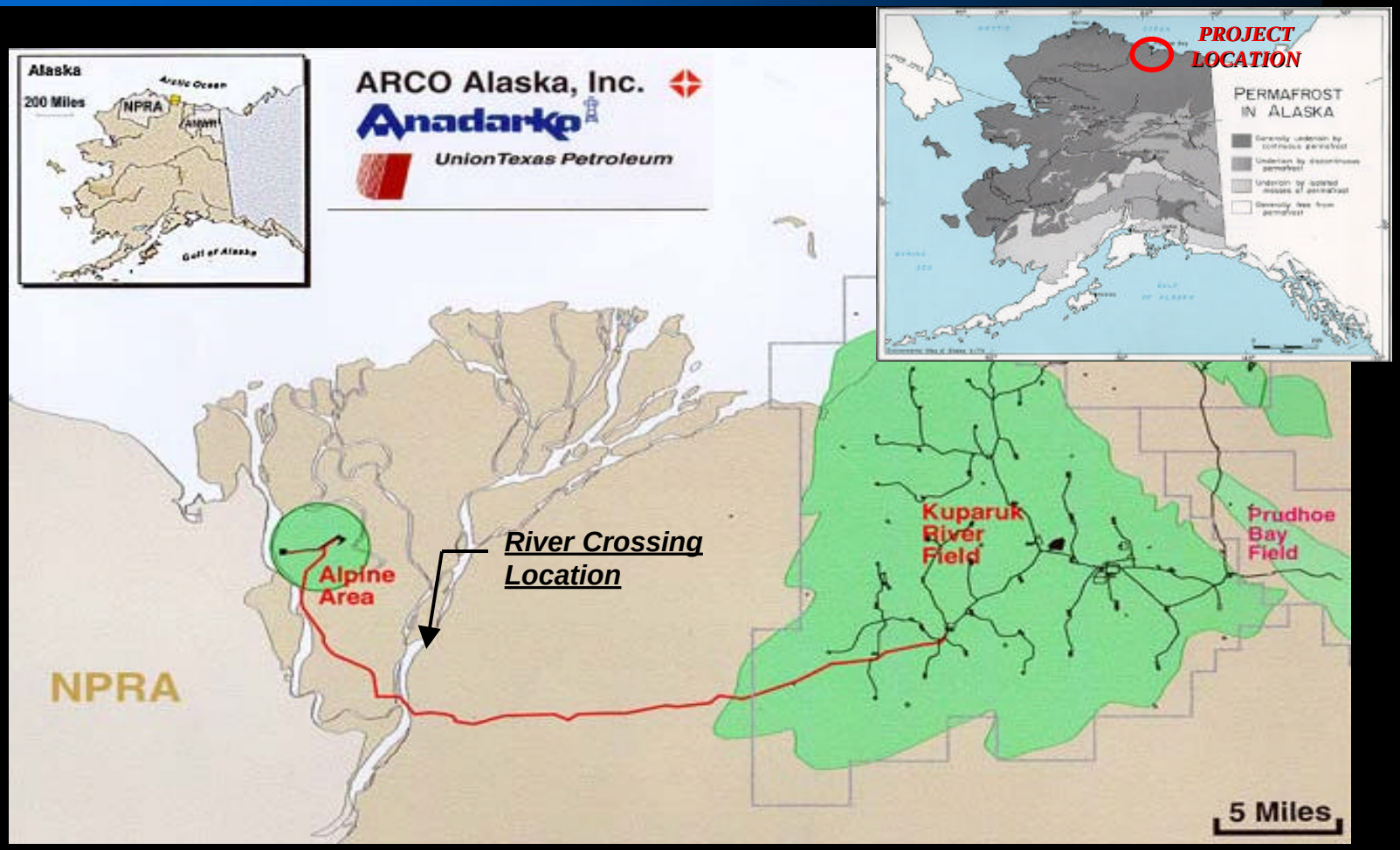
- Pipeline Support Contractor

Horizontal Drilling International

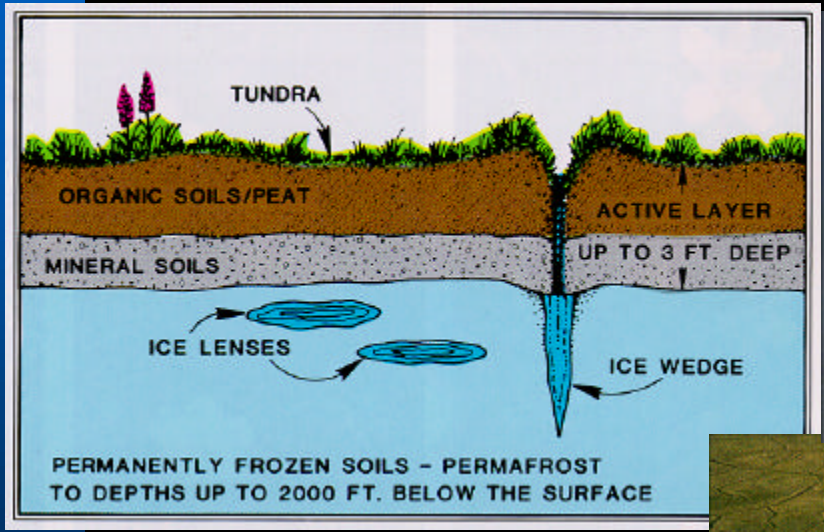
- Crossing Installation Contractor

Project Overview

Alpine Development - Location Map



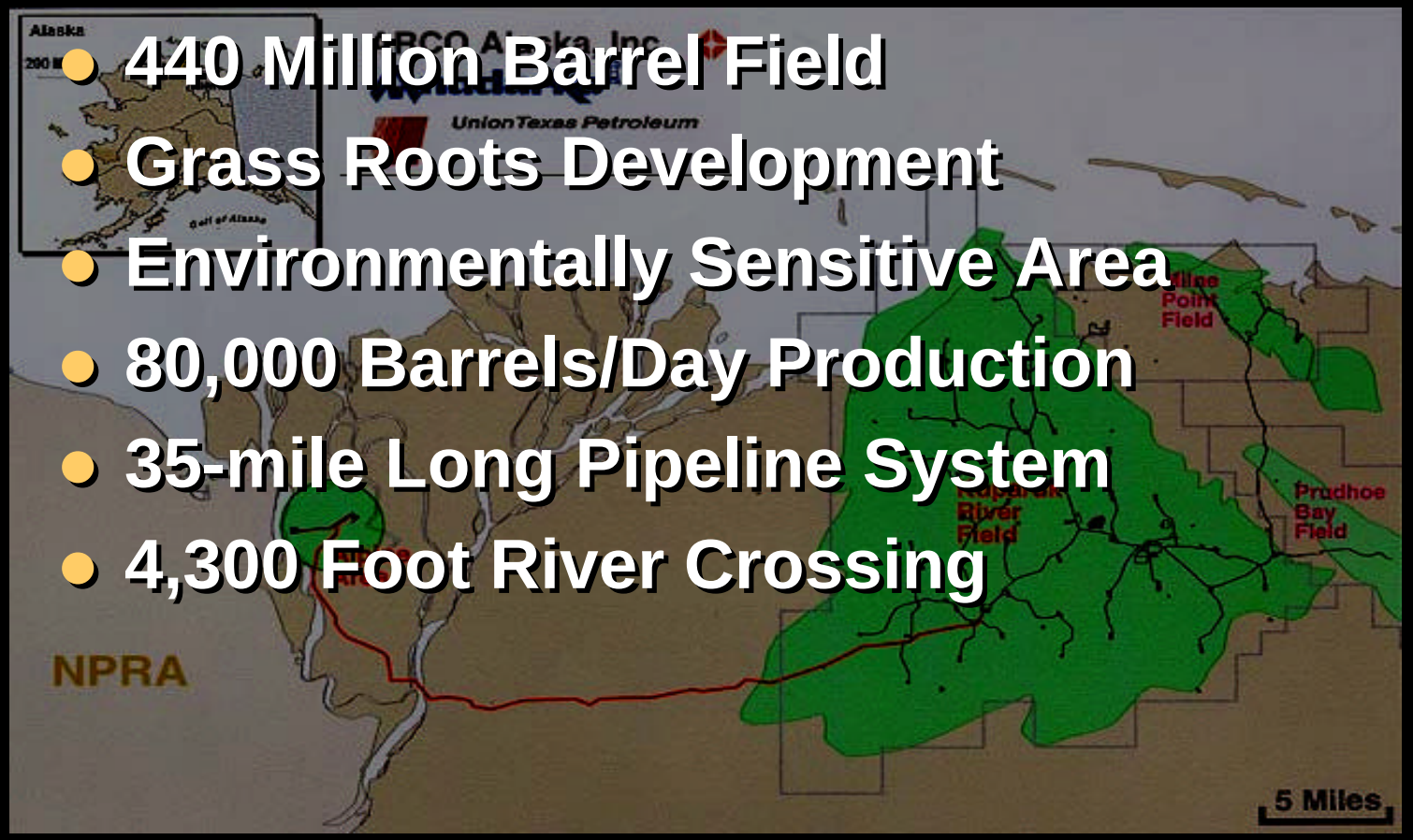
Project Ground Conditions



The Wintertime View

Project Overview

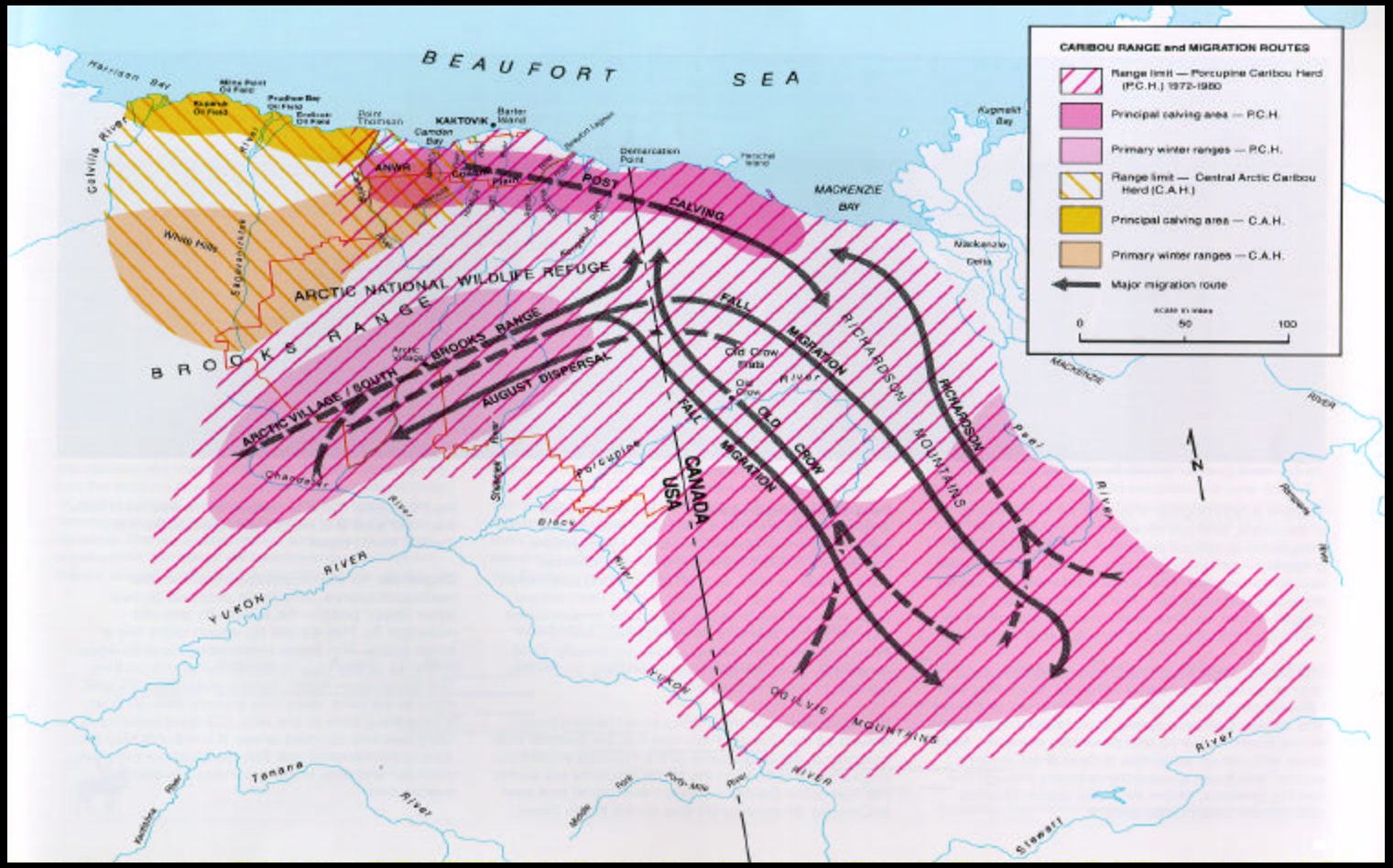
Specifics



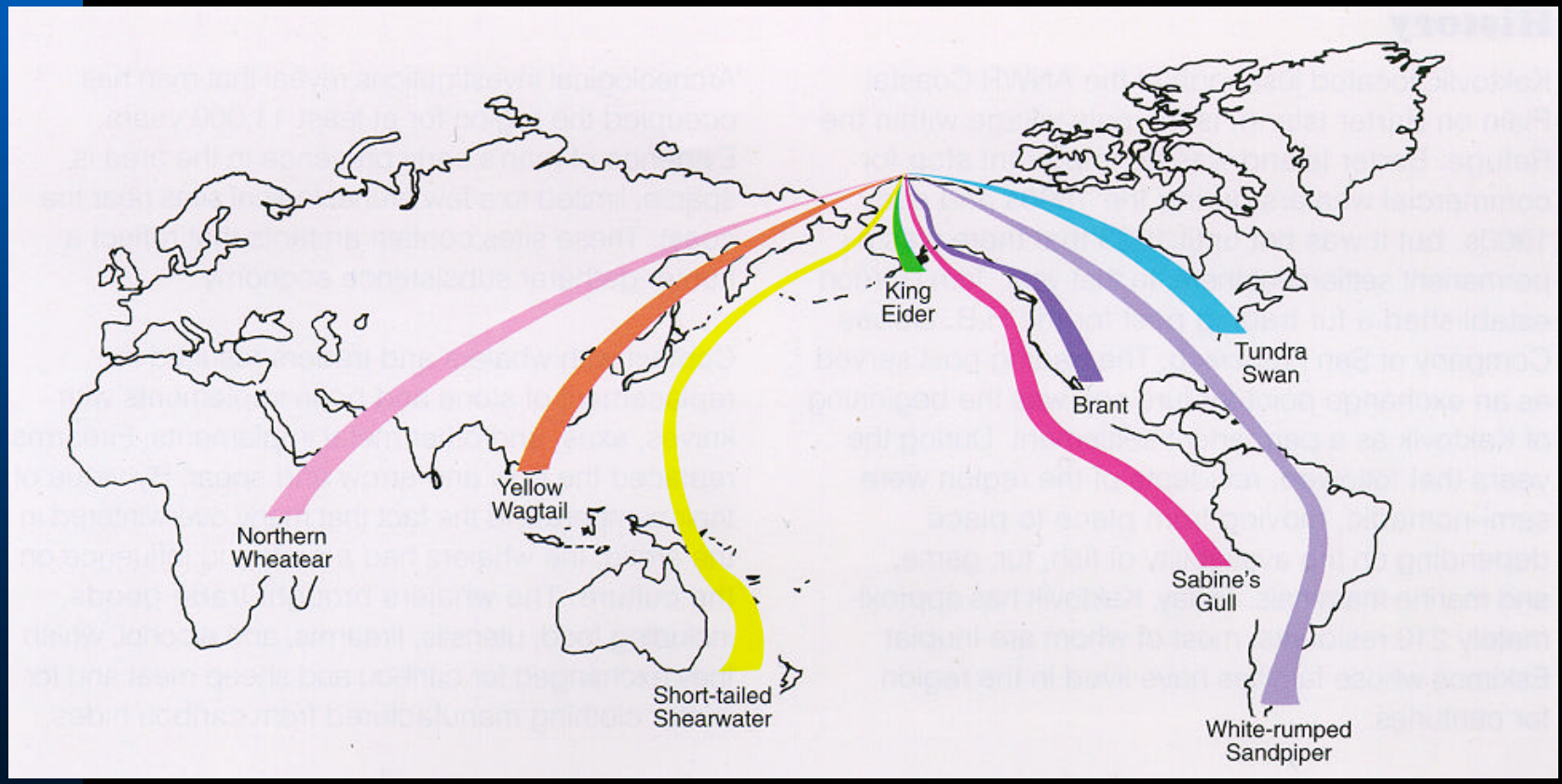
- 440 Million Barrel Field
- Grass Roots Development
- Environmentally Sensitive Area
- 80,000 Barrels/Day Production
- 35-mile Long Pipeline System
- 4,300 Foot River Crossing

Delta Conditions - ‘96 Breakup

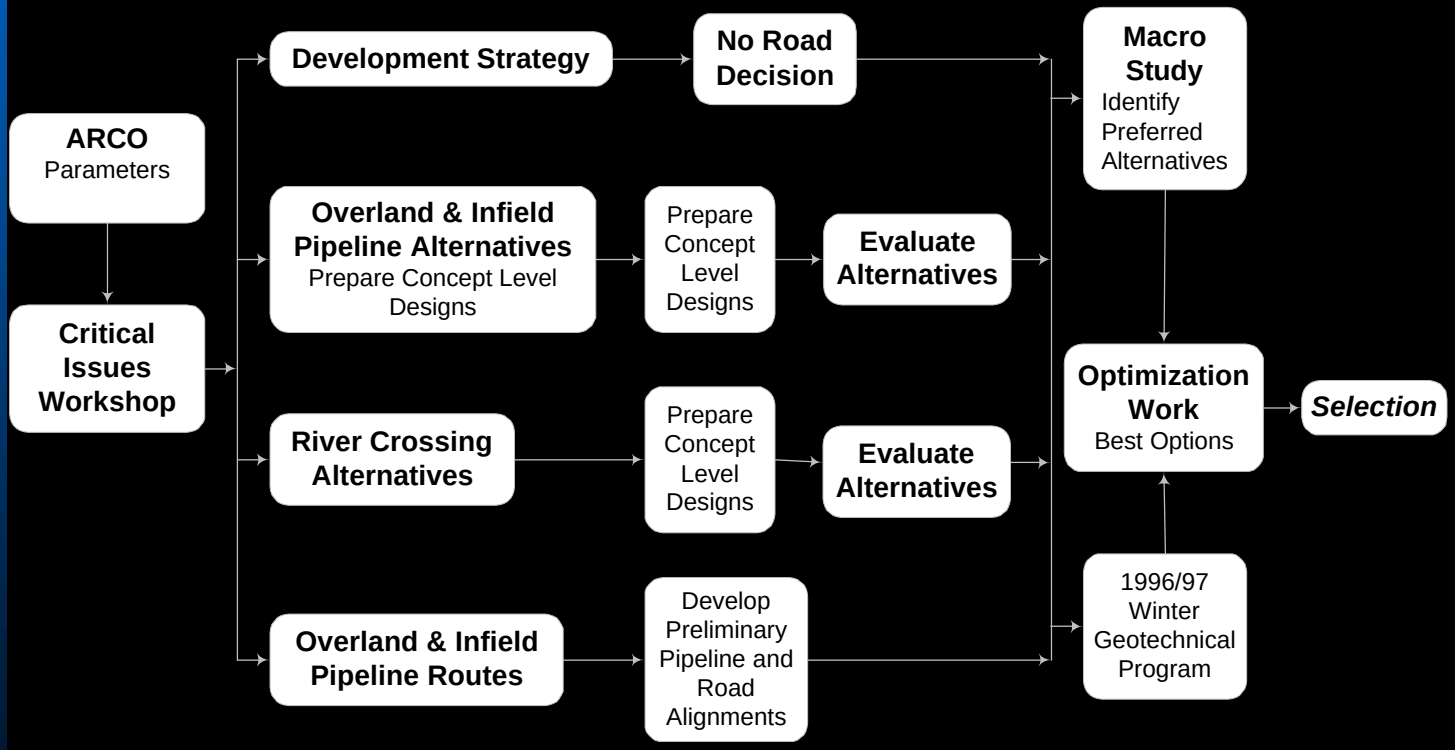
Caribou Migration



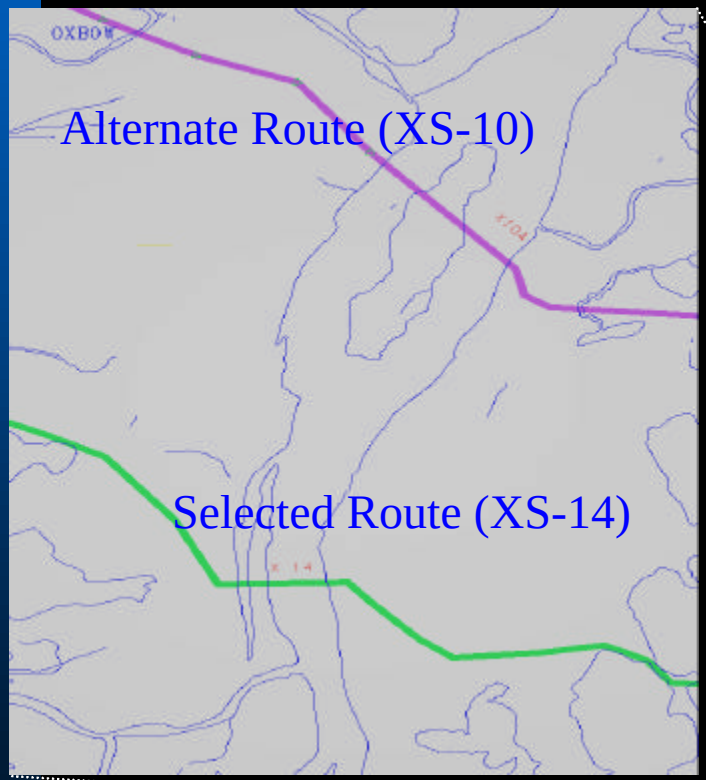
Bird Habitat



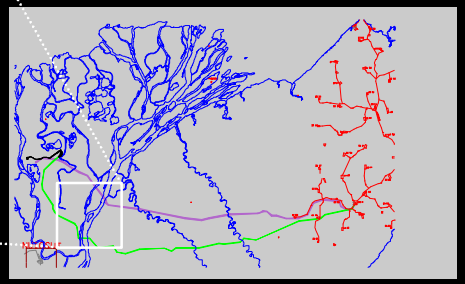
Crossing Location *f(* Larger Issues)



Crossing Location Selection



- Cross-Section 14 shorter (4,200 vs 10,000 feet)
- Longer Pipeline Route for 14 (30 vs 34 miles)
- No In-Delta Water Xings w/14
- Soil Strata Less Defined at 10

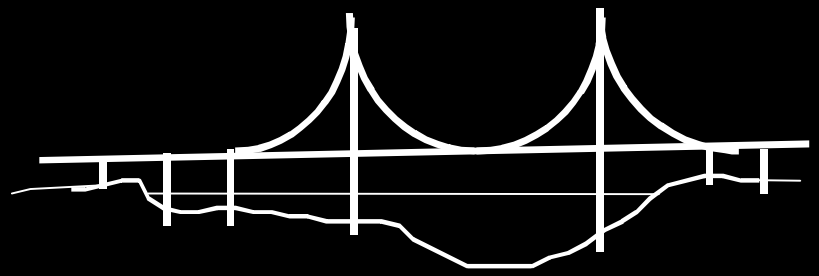


Crossing Design - East Channel

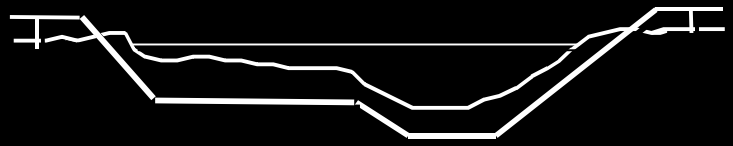
- 4 Pipeline Crossings: 4,300 Feet Each
- 14-inch Crude Oil: 20-inch Casing
- 12-inch Seawater: 18-inch Casing
- 8-inch Utility Casing: Diesel/Fiber Optics
- 8-inch Anode: Cathodic Protection

Crossing Mode Alternatives

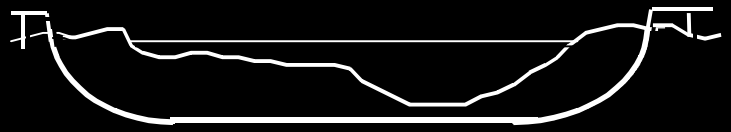
- Suspension Bridge



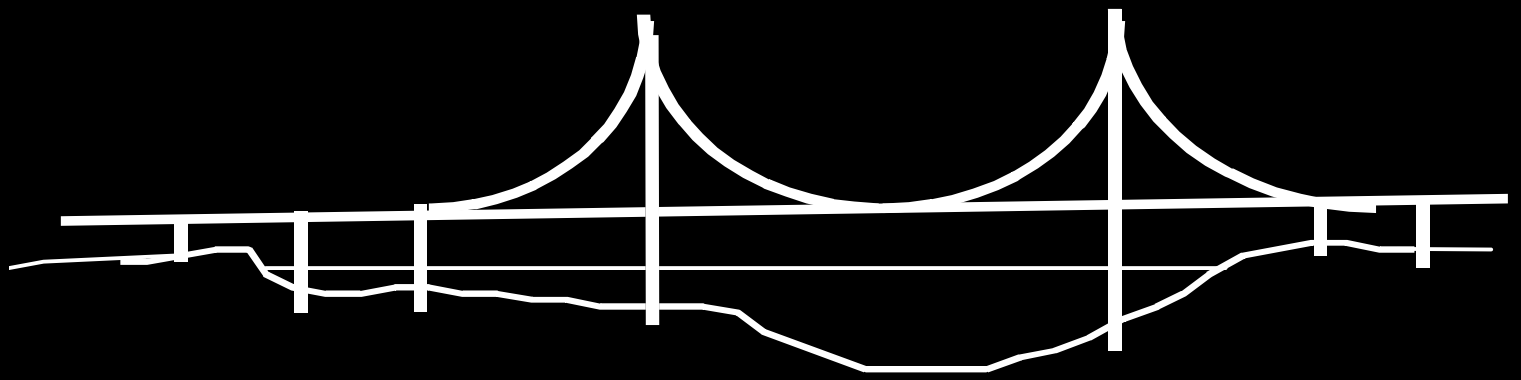
- Trench



- HDD

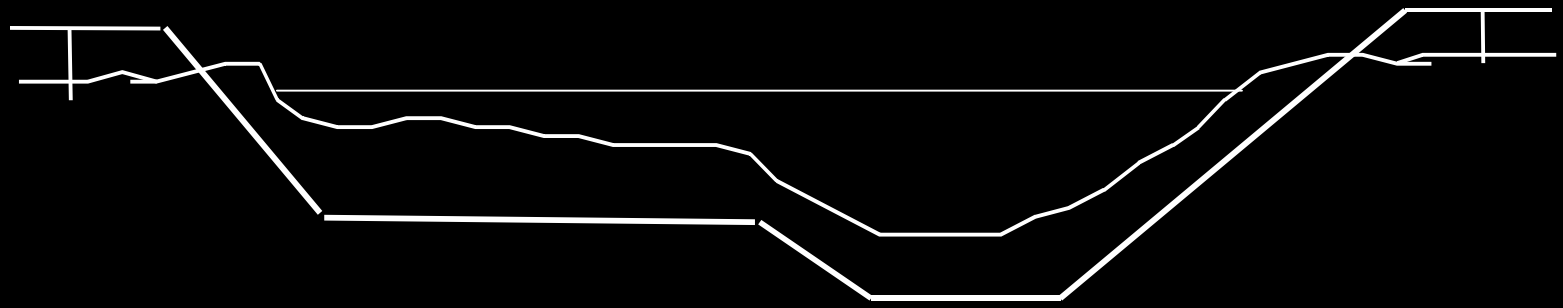


Suspension Bridge Alternative



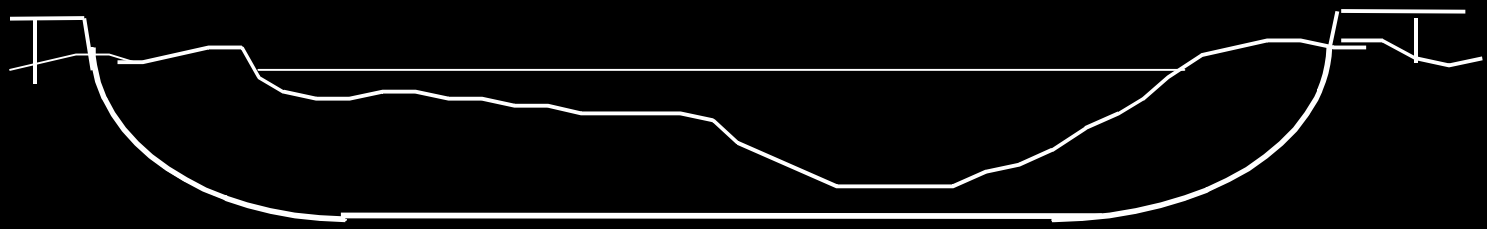
- Advantages
  - Less Subsurface Impact
  - Easy to Monitor/Inspect
  - No Corrosion Issues
  - Future Lines at Little Cost
- Disadvantages
  - Construction Over/In River
  - Highest Labor/Equip Impacts
  - 2 Construction Seasons
  - High Visual Impact
  - High Removal Cost

Trenched Alternative



- Advantages
  - Buried - Protected w/Low O&M
  - Retired In Place
  - Not Limited by Length.
- Disadvantages
  - Extensive Work In the River
  - Impacts to Fish/River Activity
  - Requires Cathodic Protection
  - Future Lines Expensive
  - 2 Seasons Construction

Horizontal Directionally Drilled



- **Advantages**
  - Small Construction Footprint
  - Lowest Labor/Equip Impact
  - No Work In/Over River
  - No Impact - Fish/river Activity
  - Shortest Construction Duration
  - Buried - Protected W/Low O&M
  - Retired in Place
  - Length OK W/ HDD Technology
- **Disadvantages**
  - Subsurface Sensitive
  - Requires Cathodic protection
  - Future Lines Expensive
  - No History in the Arctic

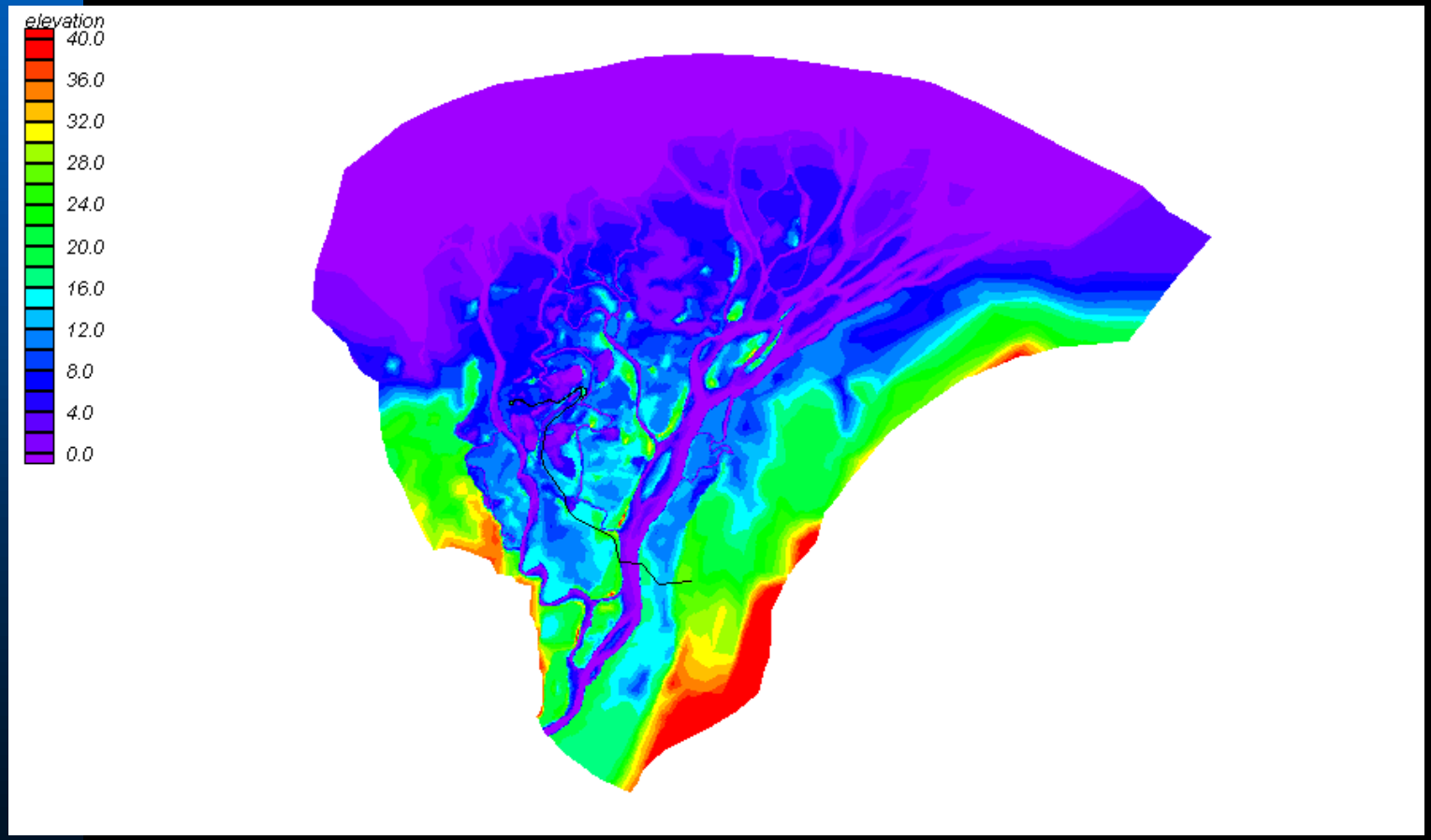
River Crossing Design Sequence

- Geotech Program
- Thermal Modeling
- Thaw Settlement
- Strain Based Design

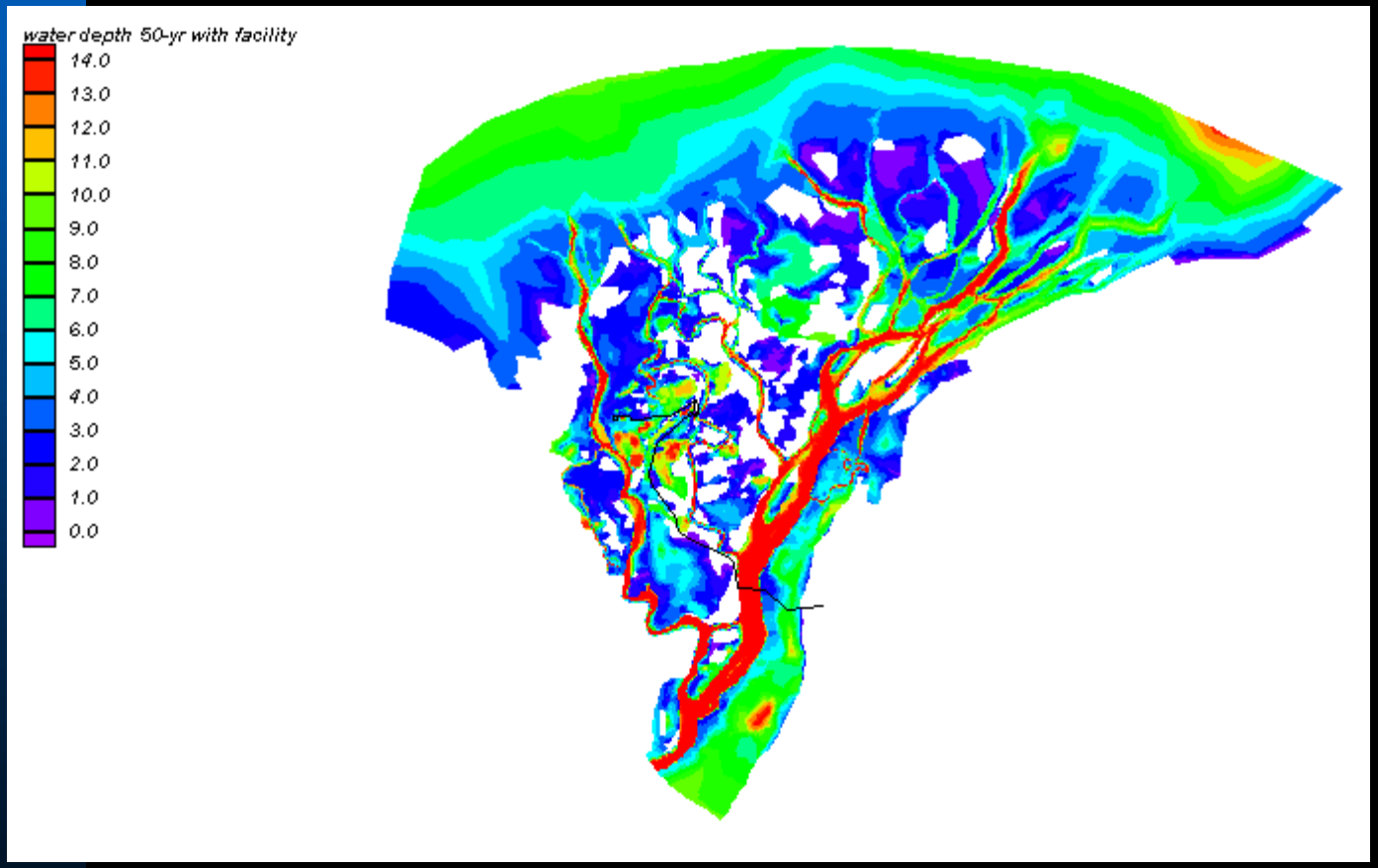
- Pipe Coating
- Cathodic Protection

- Materials
  - Tensile (yield/ultimate)
- Welding
  - Need low fy/fu
  - Low Heat Procedure
  - CTOD
  - Mod. Acceptance Criteria
  - Enhanced NDE

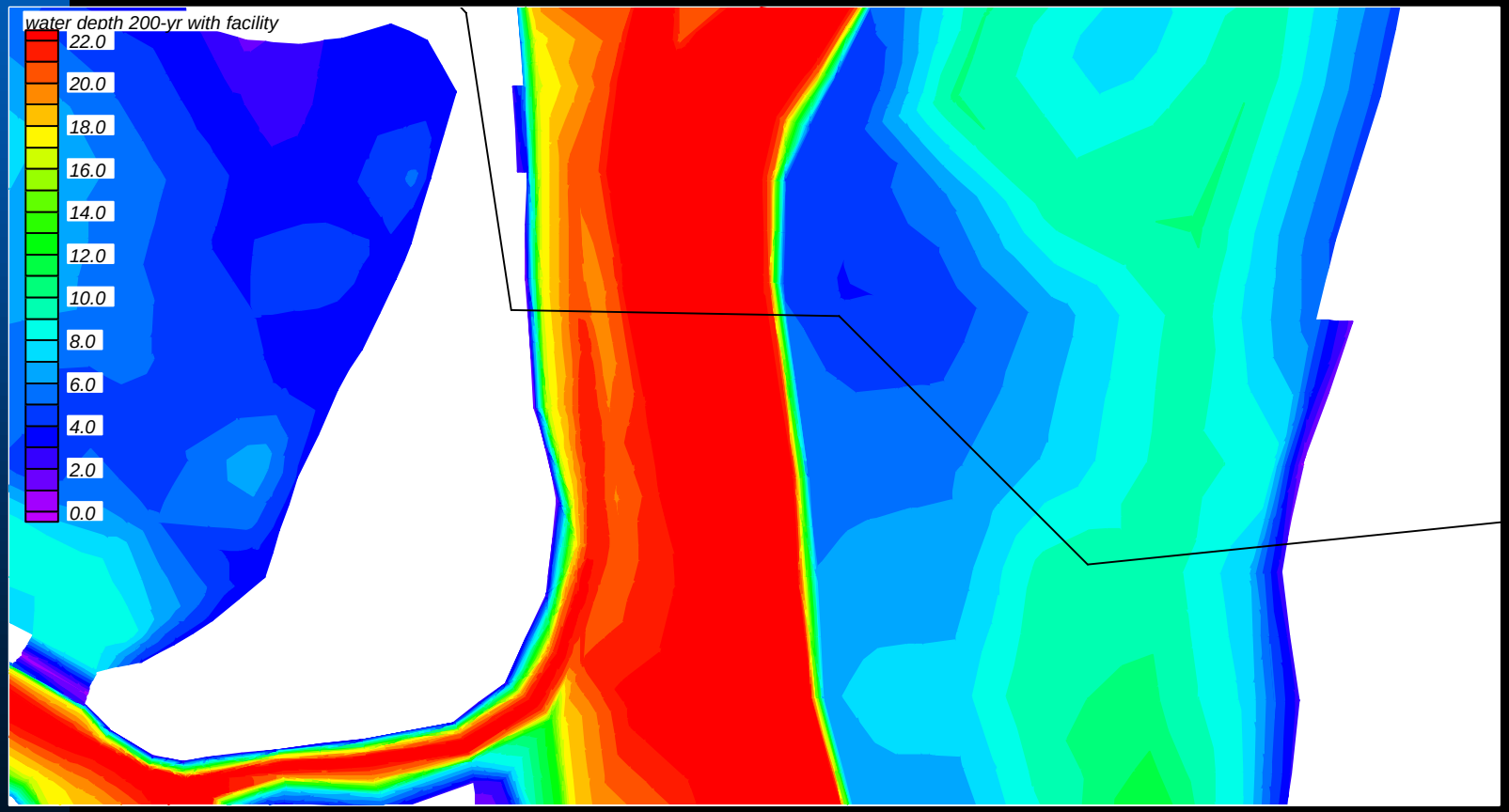
2D Model Ground Elevations



Water Depths with 50 yr. Event

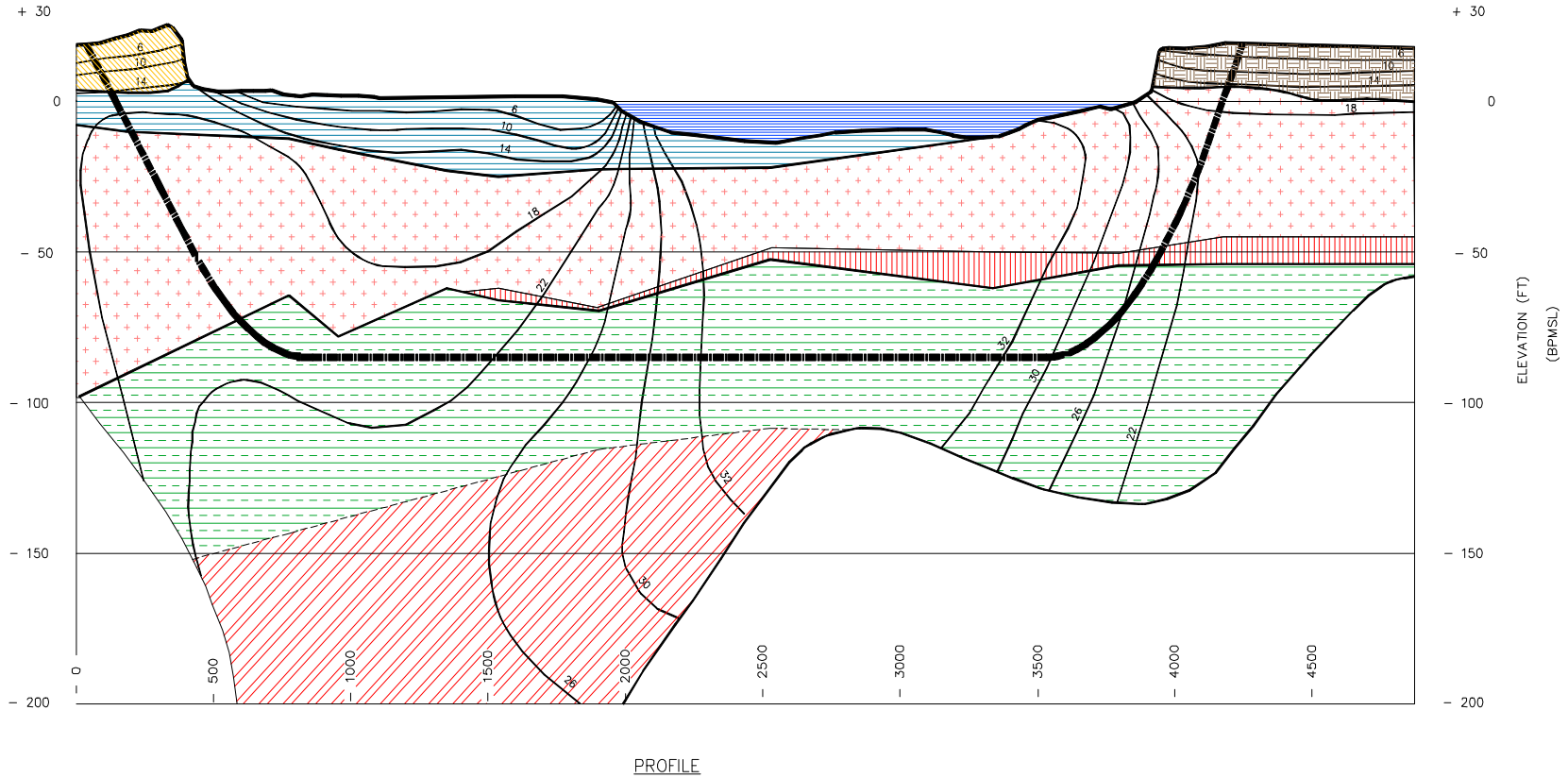


200 year Event @ River Crossing



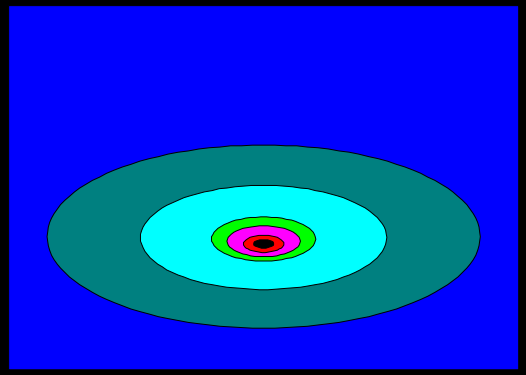
Horizontal Directional Drilling

Crossing Soils & Design Profile

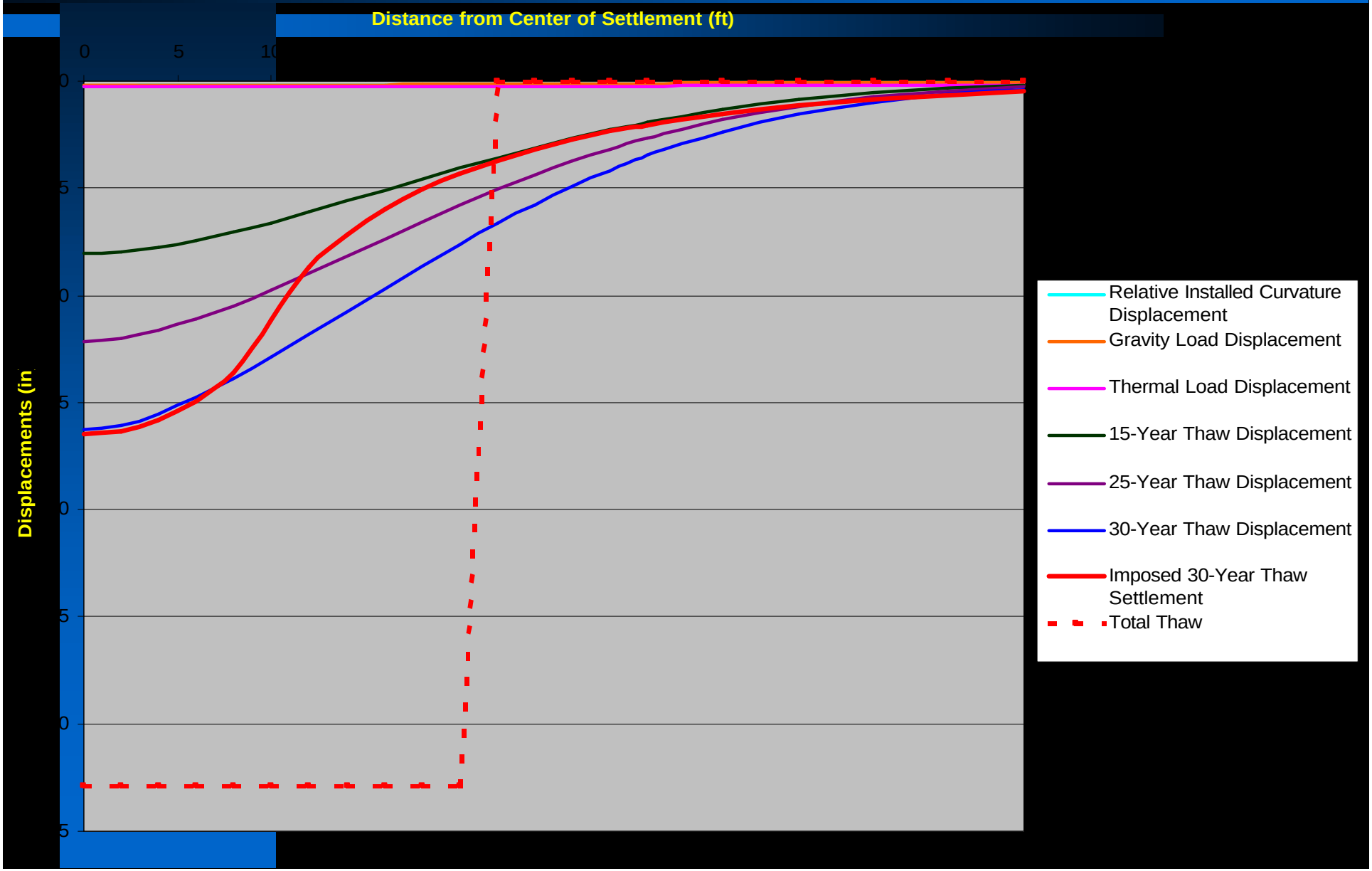


Thermal Modeling

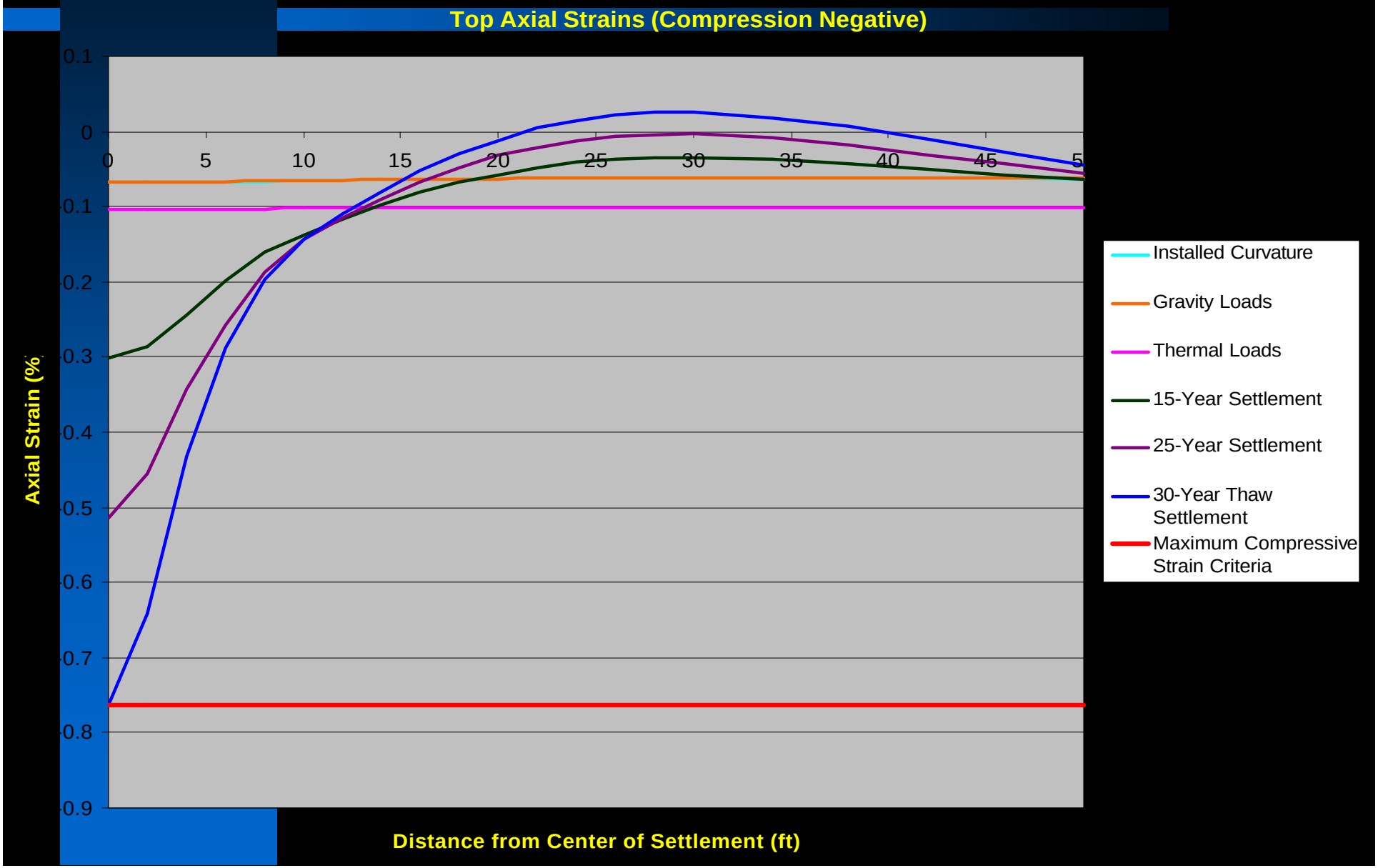
- For hot pipelines buried in permafrost
- Or for cold pipelines buried in thawed frost susceptible soils
- Thaw/frost bulb diameter coupled with thaw settlement or heave predictions from the geotechnical program
- Results used to predict strain in pipeline



Predicted Displacement Profile



Predicted Strain Profile



Execution Critical Success Factors

- Effectively Mobilize, Execute and De-mobilize
  - Leave Nothing Behind but the Pipeline
- Correct Adjustment of HDD for Arctic Conditions
  - Drill Slurry (Mud) Design
  - Cold Weather Outfitting of Equipment and Enclosures
  - Staffing for 24 Hour, Remote Location Effort
- Successful Insertion of Specialty Contractor Into North Slope Project Environment
  - Safety
  - Production
  - Schedule
  - Quality

Horizontal Directional Drilling

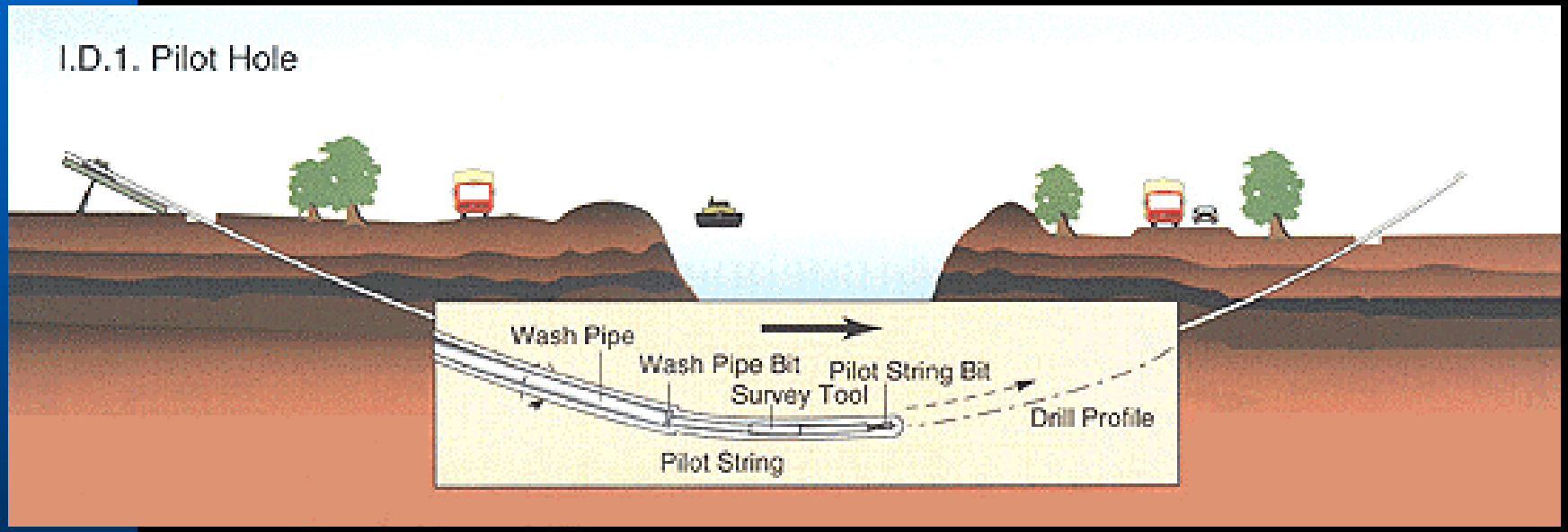
Horizontal Directional Drilling

Typical HDD Crossings

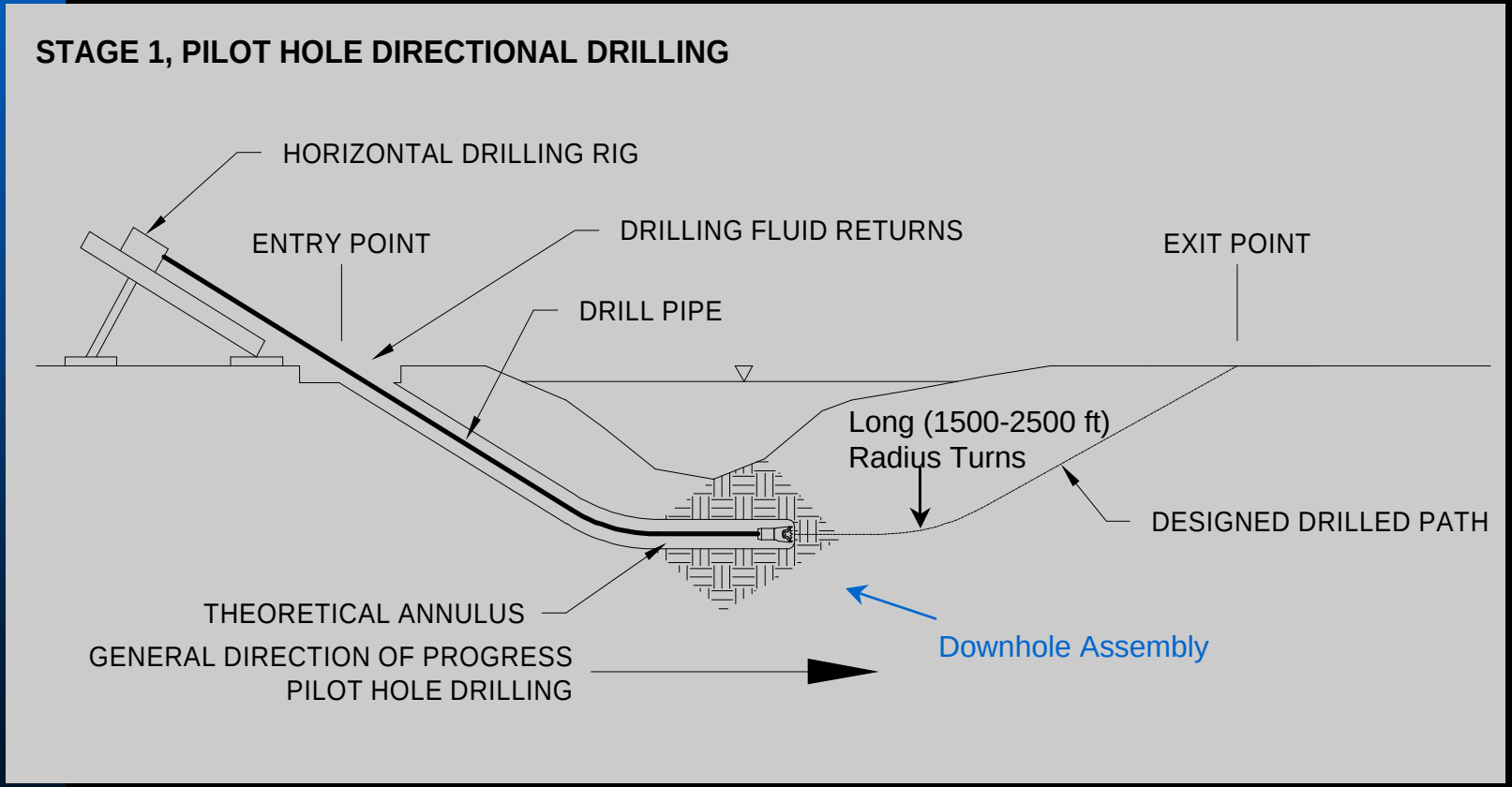
- Rivers, Canals, Estuaries
- Roads, Freeways
- Protected Habitat - Wetlands and Nesting Areas
- Shore Approaches
- Other Buried Utilities

Horizontal Directional Drilling

Pilot Hole

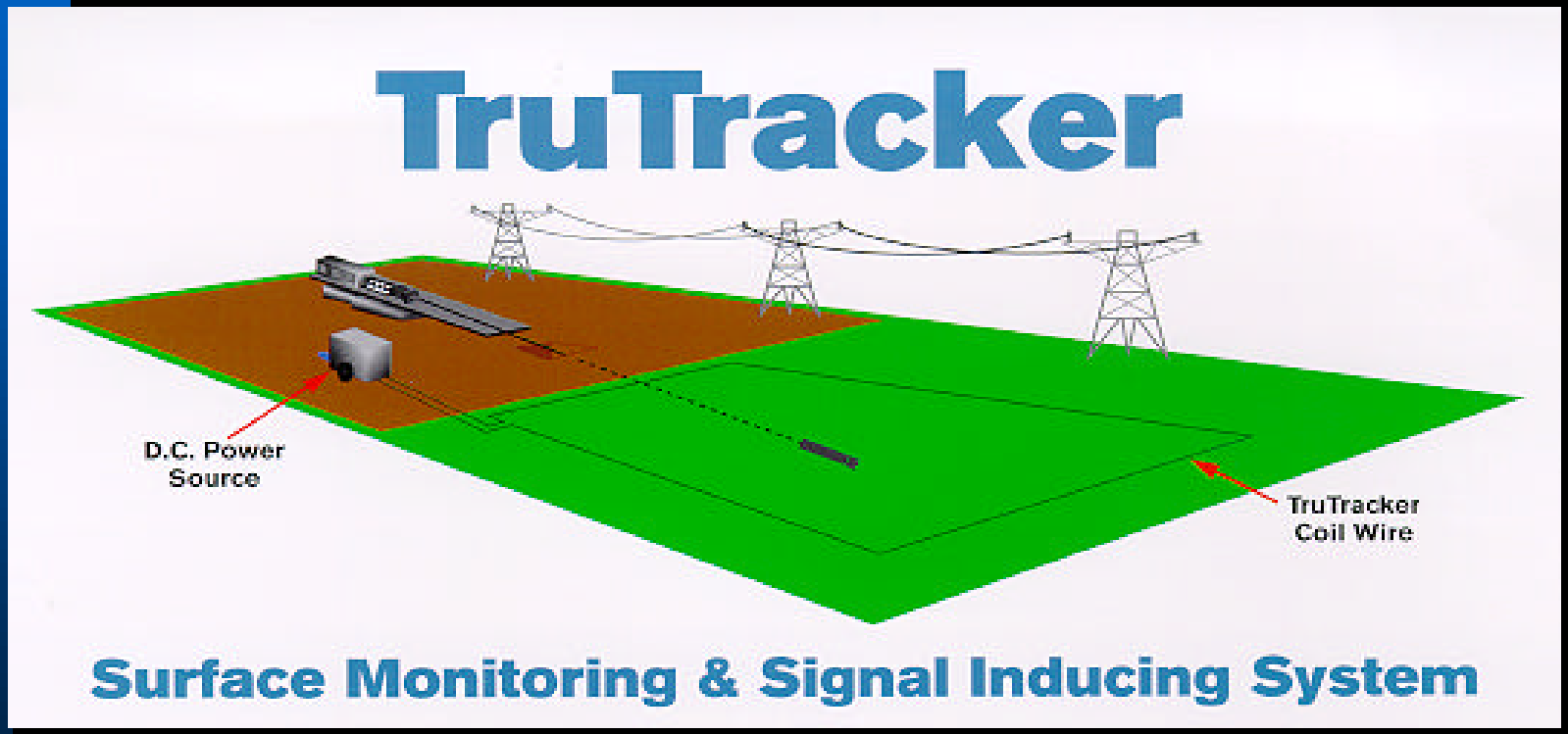


Pilot Hole Drilling Schematic



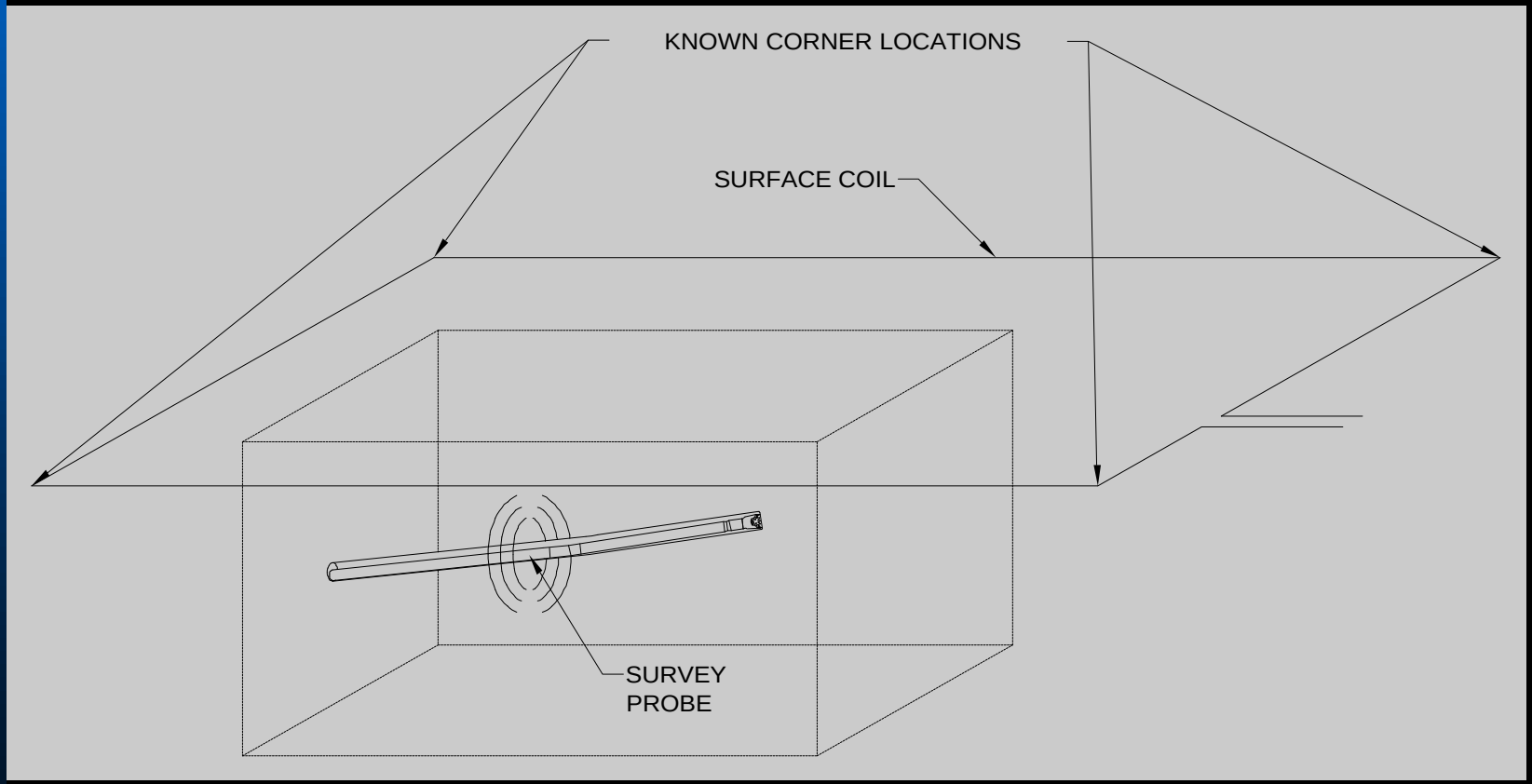
Technologies

TruTracker Survey System



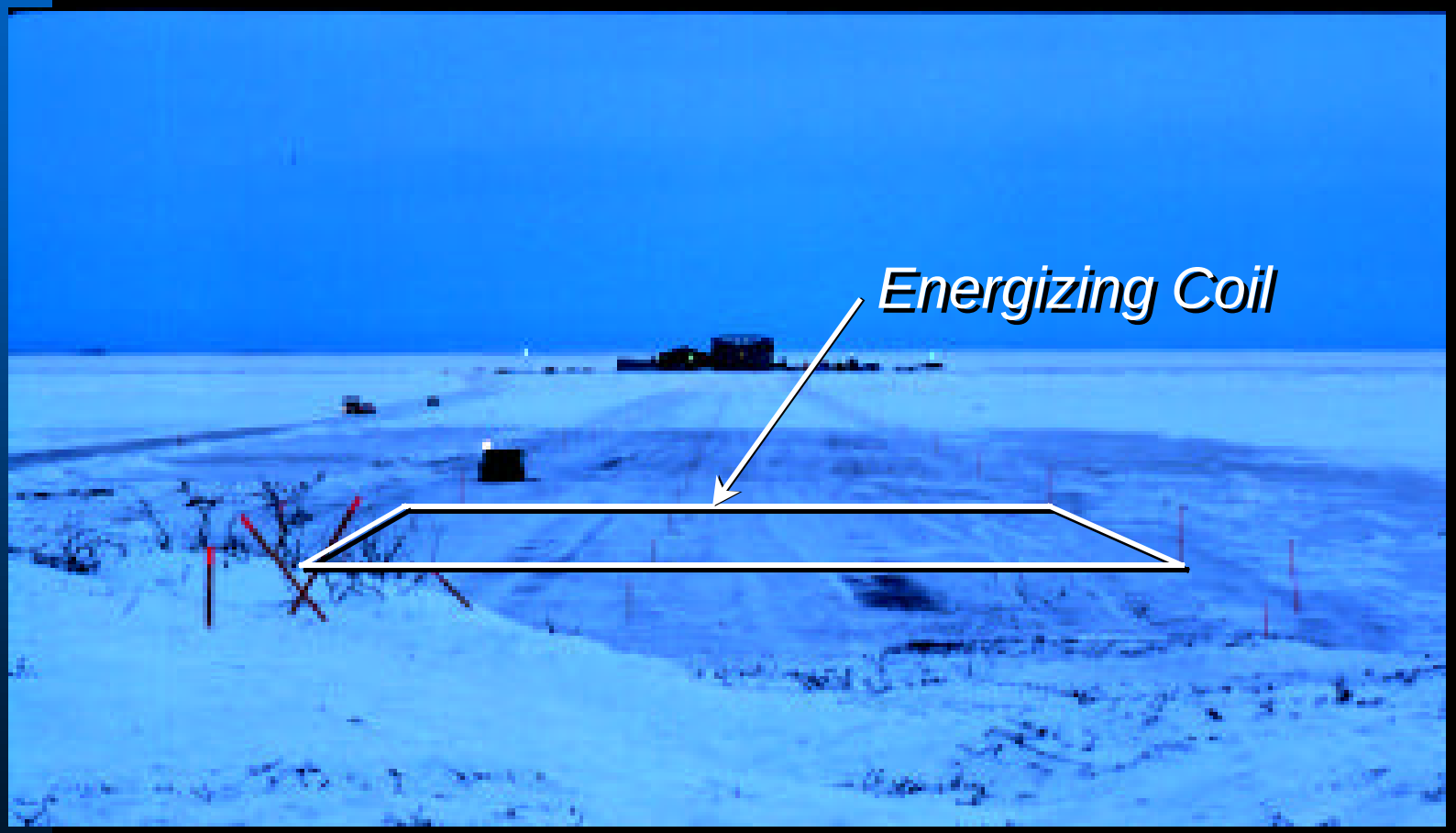
TruTracker is a Trademark of Sharewell, Inc.

Survey System Components



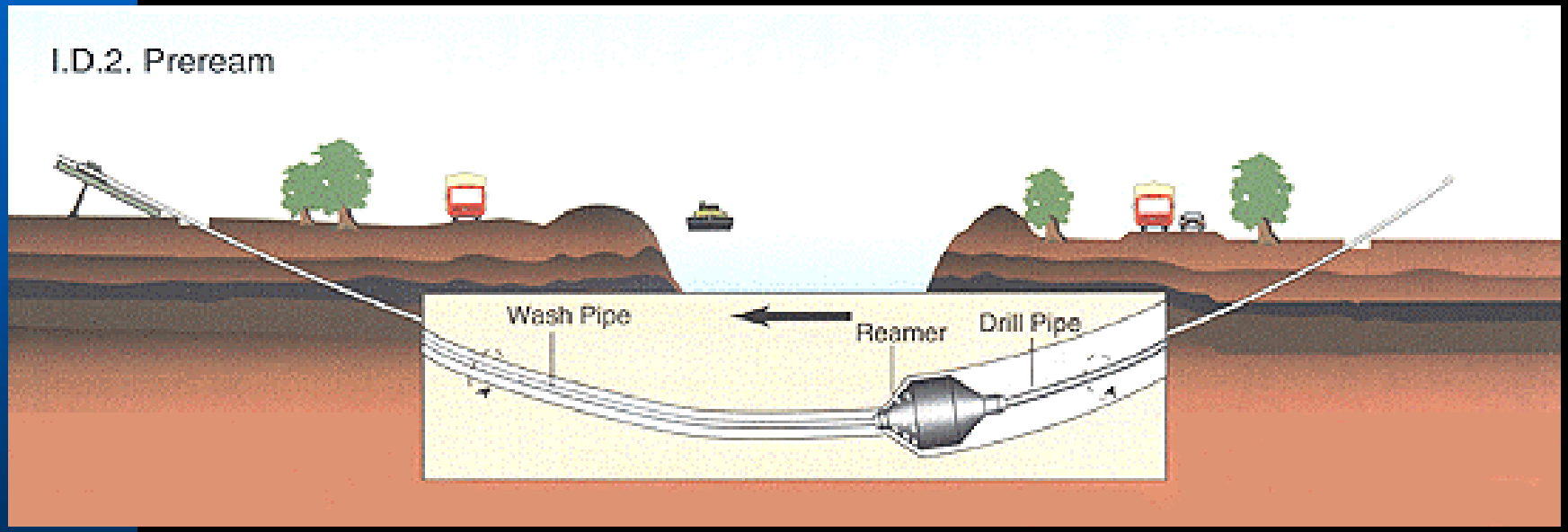
Technologies

TruTracker Grid at Colville



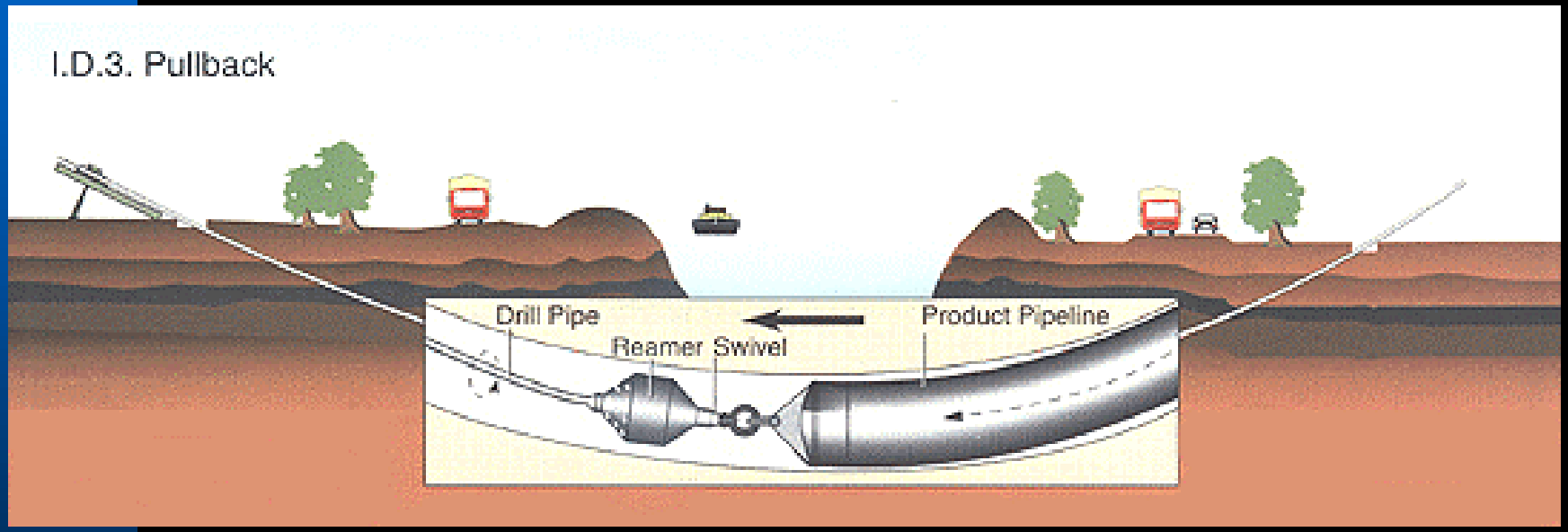
Horizontal Directional Drilling

Reaming



Horizontal Directional Drilling

Pullback



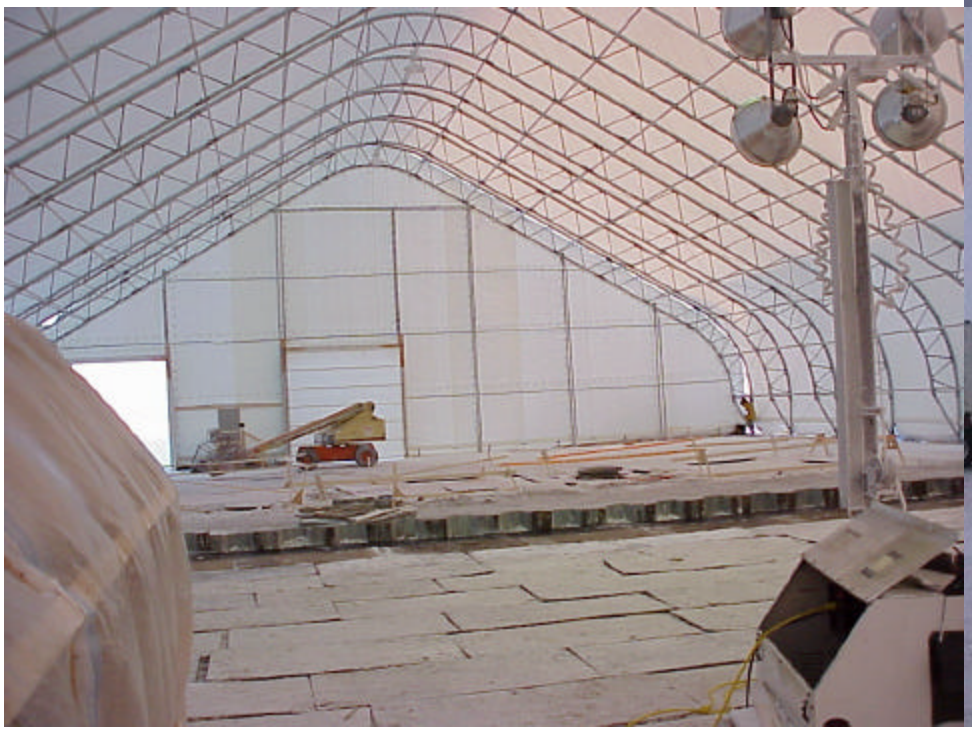
Construction Infrastructure and Logistics

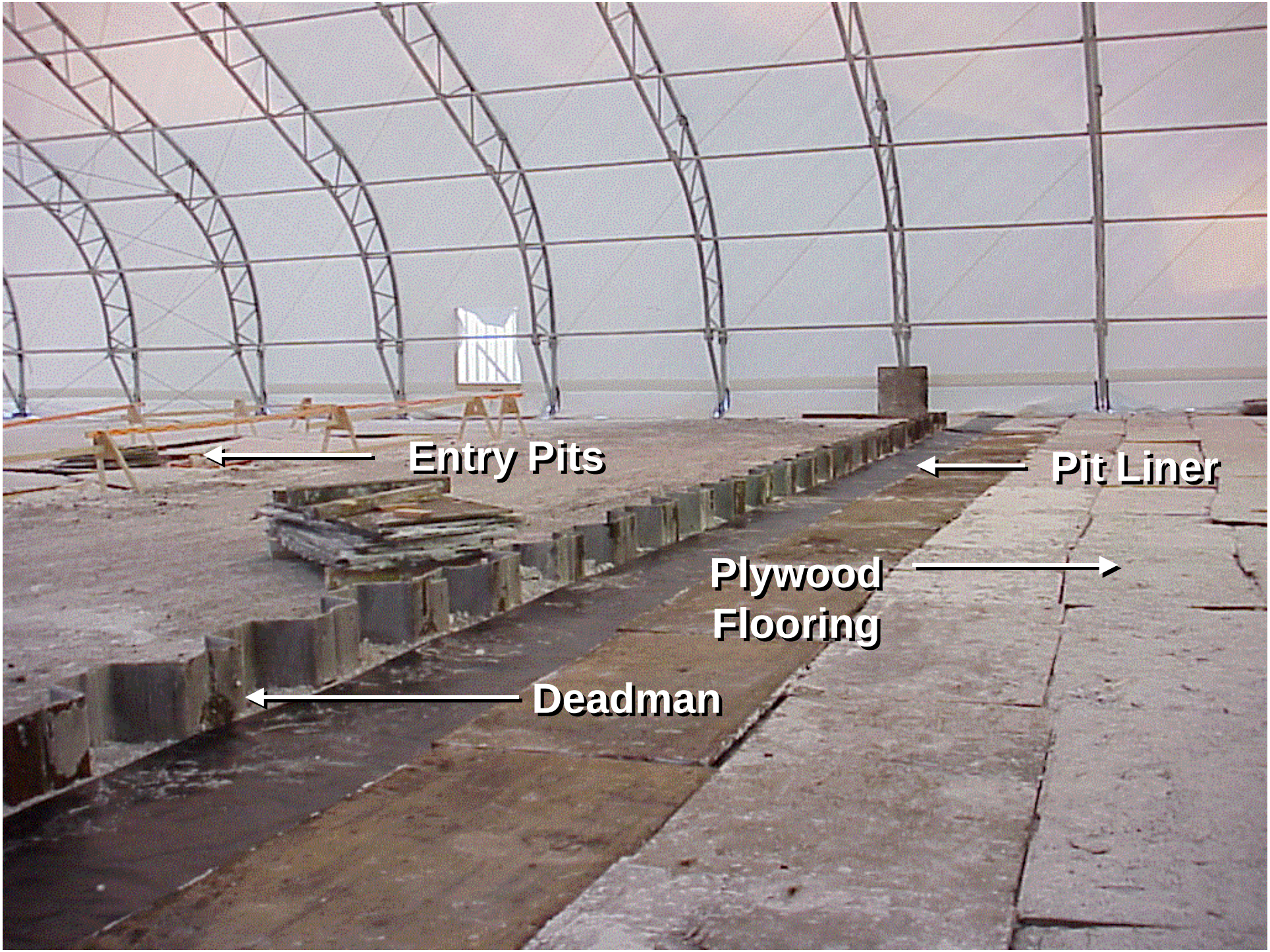
Pre-Drilling Equipment

Ice Roads & Pads

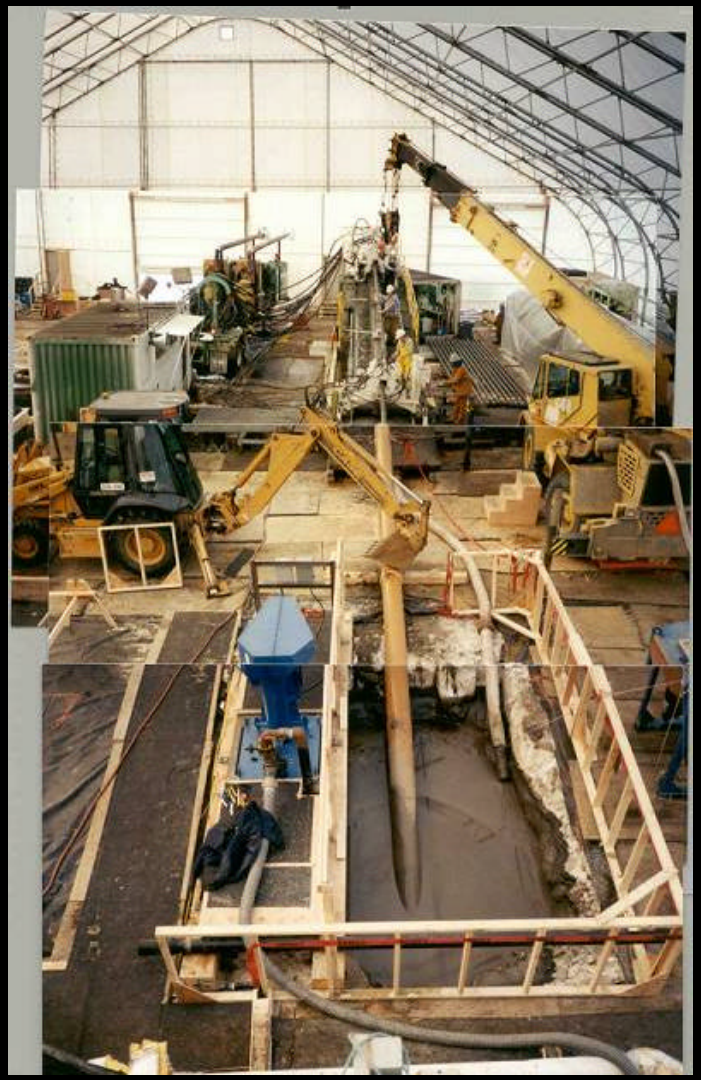
- Construct Site Access & Service Roads
- Construct HDD Ice/snow Work Pads
- Construct Ice/Snow ROW Road From HDD Site to Alpine Pad

Shelters, West
(-50 Degrees Fahrenheit, January 17, 1999)




Entry Pits
Pit Liner
Plywood
Flooring
Deadman

Shelter Operations



- All Drilling Operations Indoors
- Shelter Maintained at 40-45ºF

Colville River Crossing Construction Camp

- Housed 100 People
- Fully Contained Complex